FORM PTO-1390 (Modified) (REV 11-98) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: PF980078

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR): 09/831085

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/FR99/02599	05October 1999 (05.10.99)	05November1998 (05.11.98)

TITLE OF INVENTION

METHOD FOR SYNCHRONIZING A LOCAL CLOCK ON A CORDLESS COMMUNICATION NETWORK CLOCK

APPLICANT(S) FOR DO/EO/US

Patrick Lopez, Vincent Demoulin, Renaud Dore, Gilles Straub

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98. with references attached
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☒ Certificate of Mailing by Express Mail
20. Return postcard receipt

CERTIFICATE OF MAILING UNDER 37 CFR 1.10

EL685391093US — "Express Mail" mailing no.

May 3, 2001 — Date of Deposit

I hereby certify that this application is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

DAVIDA FORNAROTTO — Typed or printed name of person mailing application

Davida Fornarotto — Signature of person mailing application

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/831085	PCT/FR99/02599	PF980078

21. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

- ☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO and International Search Report not prepared by the EPO or JPO $1000.00
- ☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but Internation Search Report prepared by the EPO or JPO $860.00
- ☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $710.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) $690.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00

CALCULATIONS PTO USE ONLY	
ENTER APPROPRIATE BASIC FEE AMOUNT =	860.00
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	17 - 20 =	0	x $18.00	
Independent claims	1 - 3 =	0	x $80.00	
Multiple Dependent Claims (**check if applicable**).			☐	

TOTAL OF ABOVE CALCULATIONS =	860.00
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) **(check if applicable).** ☐	
SUBTOTAL =	860.00
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +	
TOTAL NATIONAL FEE =	860.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).** ☐	
TOTAL FEES ENCLOSED =	860.00
Amount to be: refunded	$
charged	$ 860.00

☐ A check in the amount of to cover the above fees is enclosed.

☒ Please charge my Deposit Account No. 07-0832 in the amount of $860.00 to cover the above fees.
A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. 07-0832 A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Mr. Joseph S. Tripoli
THOMSON multimedia Licensing Inc.
Patent Department
PO Box 5312
Princeton, New Jersey 08540

01 MAY -7 AM 10:43

Paul P. Kiel
SIGNATURE

Paul P. Kiel
NAME

40,677
REGISTRATION NUMBER

May 3, 2001
DATE

EXPRESS MAIL LABEL NO. EL685391093US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Patrick Lopez, Vincent Demoulin, Renaud Dore, Gilles Straub

Filed : Herewith

For : METHOD FOR SYNCHRONIZING A LOCAL CLOCK ON A CORDLESS COMMUNICATION NETWORK CLOCK (as per the Preliminary Amendment)

PRELIMINARY AMENDMENT

Hon. Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Sir:

In the US national phase application of PCT/FR99/02599 filed herewith, please enter the following amendments:

IN THE TITLE:

Page 1, lines 1-2, delete the current title and insert the new title as follows: -- METHOD FOR SYNCHRONIZING A LOCAL CLOCK ON A CORDLESS COMMUNICATION NETWORK CLOCK --

IN THE SPECIFICATION:

Please amend the specification as follows:

On Page 1, insert the following paragraph immediately following the title:

-- This application claims the benefit of French application serial no. 9813939 filed November 5, 1998, which is hereby incorporated herein by reference, and which claims the benefit under 35 U.S.C. § 365 of International Application PCT/FR99/02599, filed October 5, 1999, which was published in accordance with PCT Article 21(2) on May 18, 2000 in French.--

IN THE CLAIMS:

Please amend the claims as follows: A marked up version of the amended claims is attached herewith:

1.(AMENDED) A method for synchronizing a local clock of a piece of apparatus to a clock of a wireless communications network to which said apparatus is linked, wherein, with the frames being transmitted according to a TDMA-type mode, said method includes the following stages:

- a stage of determining the timing-phase shift between the network clock which is received on a receiving channel and the local clock of the apparatus,
- a stage of correcting the local clock of the apparatus on the receiving channel as a function of said phase shift determined, via a first correction of the integer part of the phase shift in the time domain and a second correction of the fractional part for recovery of the residual phase shift.

2.(AMENDED) The method according to Claim 1, wherein, one check window per frame being assigned to each sending apparatus of the wireless network, the determination stage includes a stage of detecting a non-varying pattern present at the start of each check window assigned to a piece of apparatus which is the sender of the network clock, said pattern making it possible to supply the instant corresponding to the clock pulse of the network.

3.(AMENDED) The method according to Claim 2, wherein the detection stage is carried out by correlation between the network-clock pulse and that of the local clock of the apparatus.

4.(AMENDED) The method according to Claim 1, wherein the determination stage includes a stage of slaving of the network-clock pulse.

5.(AMENDED) The method according to Claim 1, wherein said correction of the integer part is achieved by phase-shifting of the local-clock pulse to a sub-multiple of the sampling period of the apparatus.

6.(AMENDED) The method according to Claim 1, wherein said second correction of the fractional part is achieved in the frequency domain by rotation of vectors expressing the samples received.

7.(AMENDED) The method according to Claim 1, wherein said stage of determining the timing-phase shift is employed for a third integer-part correction of said phase shift and a fourth fractional-part correction to be carried out on the local clock sent on a sending channel.

8.(AMENDED) The method according to Claim 7, wherein said fourth correction is carried out in the frequency domain by interpolation of the vectors expressing the samples sent.

9.(AMENDED) The method according to Claim 7, wherein the fractional-part corrections are carried out in the time domain by interpolation.

10.(AMENDED) The method according to Claim 7, wherein the phase shift introduced on the sending channel is greater than that introduced on the receiving channel.

11.(AMENDED) A synchronization device suitable for implementing the method according to Claim 1, for synchronizing a local clock of a piece of apparatus to the clock of a wireless communications network to which said apparatus is linked, wherein, with the frames being transmitted according to a TDMA-type mode, said device includes:

- means for determining the timing-phase shift between the network clock received on a receiving channel and the local clock of the apparatus,

- a first set of means for correcting the apparatus' local clock on the receiving channel as a function of said phase shift determined, comprising first means for correcting the integer part of the phase shift in the time domain and second means for correcting the fractional part of the phase shift able to recover the residual phase shift.

12.(AMENDED) The device according to Claim 11, wherein said determination means comprise a correlator intended for supplying the clock pulse of the network to within a sub-multiple of the sampling period of the device, and a local-clock slaving unit or locking the local clock to the network clock.

13.(AMENDED) The device according to Claim 11, wherein said first set of correction means comprises:

- a first unit for timing-phase shifting to the receiving channel for phase-shifting the local-clock pulse by a delay corresponding to the integer part of said phase shift determined,

- a first processing unit for the phase-shifting corresponding to the fractional part determined on the receiving channel.

14.(AMENDED) The device according to Claim 11, wherein said synchronization device comprises a second set of means for correcting the local clock of the apparatus on a sending channel as a function of said phase shift determined, comprising third means or correcting the integer part of the phase shift in the time domain and fourth means for correcting the fractional part able to recover the residual phase shift.

15.(AMENDED) The device according to Claim 14, wherein said second set of correction means comprises:

- a second unit for phase-shifting on the sending channel for phase-shifting the local-clock pulse by a delay corresponding to the integer part of said phase shift determined,

- a second processing unit for the phase-shifting corresponding to the fractional part determined on the receiving channel.

16.(AMENDED) The device according to Claim 15, wherein said first and second processing units respectively include a unit for calculating the Fourier transform, a unit for calculating the inverse Fourier transform, each of the processing units including a phase shifter able to apply, in the frequency domain, a rotation of the vectors representing the samples of the frame.

17.(AMENDED) The device according to Claim 15, wherein said first and second processing units respectively include an interpolator able to interpolate the phase shift corresponding to the fractional part determined and to delay the apparatus's clock by a calculated delay on the sending channel.

IN THE ABSTRACT:

Please add the following Abstract.

-- The invention relates to a method for synchronizing a local clock of a piece of apparatus to the clock of a wireless communications network to which said apparatus is connected, the network clock being sent by a reference apparatus and the frames being transmitted according to a TDMA-type mode. It is characterized by the following stages:

- a stage of determining the timing-phase shift between the network clock which is received on a receiving channel and the local clock of the apparatus,

- a stage of correcting the apparatus' local clock on the receiving channel as a function of said phase shift determined, via a first correction of the integer part of the phase shift in the time domain and a second correction, called correction of the fractional part, able to recover the additional phase shift not recovered by the first correction. Particular application in domestic wireless communications networks..--

REMARKS

The title has been amended to conform with the translated title of the published application (WO 00/28401).

The specification has been amended to include a reference to the priority applications.

The claims have been amended to remove reference indicia and to meet the requirements of the United States Patent and Trademark Office.

To meet the requirements of the United States, the Abstract (as originally filed in the PCT application) is added.

No fee is believed to have been incurred by virtue of this amendment. However if a fee is incurred on the basis of this amendment, please charge such fee against deposit account 07-0832

Respectfully submitted,
Patrick Lopez
Vincent Demoulin
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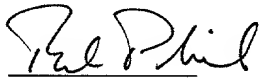
Gilles Straub



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May 3, 2001

MARKED UP VERSION OF THE AMENDED CLAIMS

1.(AMENDED) A method for synchronizing a local clock of a piece of apparatus [(WL2, WL3)] to a clock of a wireless communications network [(50)] to which said apparatus [(WL2, WL3)] is linked, [characterized in that] wherein, with the frames being transmitted according to a TDMA-type mode, said method includes the following stages:

- a stage of determining the timing-phase shift between the network clock which is received on a receiving channel [(8)] and the local clock of the apparatus [(WL2, WL3)],

- a stage of correcting the local clock of the apparatus [(WL2, WL3)] on the receiving channel [(8)] as a function of said phase shift determined, via a first correction of the integer part of the phase shift in the time domain and a second correction of the fractional part for recovery of the residual phase shift.

2.(AMENDED) The method according to Claim 1, [characterized in that] wherein, one check window per frame being assigned to each sending apparatus of the wireless network, the determination stage includes a stage of detecting a non-varying pattern present at the start of each check window assigned to a piece of apparatus [(WL1)] which is the sender of the network clock, said pattern making it possible to supply the instant corresponding to the clock pulse of the network.

3.(AMENDED) The method according to Claim 2, [characterized in that] wherein the detection stage is carried out by correlation between the network-clock pulse and that of the local clock of the apparatus [(WL2, WL3)].

4.(AMENDED) The method according to [one of Claims 1 to 3, characterized in that] Claim 1, wherein the determination stage includes a stage of slaving of the network-clock pulse.

5.(AMENDED) The method according to [one of Claims 1 to 4, characterized in that] Claim 1, wherein said correction of the integer part is achieved by phase-shifting of the local-clock pulse to a sub-multiple of the sampling period of the apparatus [(WL2, WL3)].

6.(AMENDED) The method according to [one of Claims 1 to 5, characterized in that] Claim 1, wherein said second correction of the fractional part is achieved in the frequency domain by rotation of vectors expressing the samples received.

7.(AMENDED) The method according to [one of Claims 1 to 6, characterized in that] Claim 1, wherein said stage of determining the timing-phase shift is employed for a third integer-part correction of said phase shift and a fourth fractional-part correction to be carried out on the local clock sent on a sending channel.

8.(AMENDED) The method according to Claim 7, [characterized in that] wherein said fourth correction is carried out in the frequency domain by interpolation of the vectors expressing the samples sent.

9.(AMENDED) The method according to [one of Claims 7 to 8, characterized in that] Claim 7, wherein the fractional-part corrections are carried out in the time domain by interpolation.

10.(AMENDED) The method according to [one of Claims 7 to 9, characterized in that] Claim 7, wherein the phase shift introduced on the sending channel is greater than that introduced on the receiving channel.

11.(AMENDED) A synchronization device suitable for implementing the method according to [one of the preceding claims] Claim 1, for synchronizing a local clock of a piece of apparatus [(WL2, WL3)] to the clock of a wireless communications network [(50)] to which said apparatus [(WL2, WL3)] is linked, [characterized in that] wherein, with the frames being transmitted according to a TDMA-type mode, said device includes:

- means [(10; 12; 14; 13; 130)] for determining the timing-phase shift between the network clock received on a receiving channel [(8)] and the local clock of the apparatus [(WL2, WL3)],

- a first set of means [(11; 15; 18; 21)] for correcting the apparatus' local clock on the receiving channel [(8)] as a function of said phase shift determined, comprising first means [(11)] for correcting the integer part of the phase shift in the

time domain and second means [(15; 18; 21)] for correcting the fractional part of the phase shift able to recover the residual phase shift.

12.(AMENDED) The device according to Claim 11, [characterized in that] wherein said determination means [(10; 12; 14; 13; 130)] comprise a correlator [(10)] intended for supplying the clock pulse of the network [(50)] to within a sub-multiple of the sampling period of the device [(7)], and a local-clock slaving unit [(12; 14; 13)] for locking the local clock to the network clock.

13.(AMENDED) The device according to [one of Claims 11 to 12, characterized in that] Claim 11, wherein said first set of correction means [(11; 15; 18; 21)] comprises:

- a first unit [(11)] for timing-phase shifting to the receiving channel [(8)] for phase-shifting the local-clock pulse by a delay corresponding to the integer part of said phase shift determined,

- a first processing unit [(15; 18; 21)] for the phase-shifting corresponding to the fractional part determined on the receiving channel [(8)].

14.(AMENDED) The device according to [one of Claims 11 to 13, characterized in that] Claim 11, wherein said synchronization device comprises a second set of means [(11; 17; 19; 22)] for correcting the local clock of the apparatus [(WL2, WL3)] on a sending channel [(9)] as a function of said phase shift determined, comprising third means [(16)] for correcting the integer part of the phase shift in the time domain and fourth means [(17; 19; 22)] for correcting the fractional part able to recover the residual phase shift.

15.(AMENDED) The device according to Claim 14, [characterized in that] wherein said second set of correction means [(11; 17; 19; 22)] comprises:

- a second unit [(16)] for phase-shifting on the sending channel [(9)] for phase-shifting the local-clock pulse by a delay corresponding to the integer part of said phase shift determined,

- a second processing unit [(17; 19; 22)] for the phase-shifting corresponding to the fractional part determined on the receiving channel [(9)].

16.(AMENDED) The device according to Claim 15, [characterized in that] wherein said first [(15; 18; 21)] and second [(17; 19; 22)] processing units respectively include a unit [(18)] for calculating the Fourier transform, a unit [(19)] for calculating the inverse Fourier transform, each of the processing units [((15; 18; 21); (17; 19; 22))] including a phase shifter [(15; 17)] able to apply, in the frequency domain, a rotation of the vectors representing the samples of the frame.

17.(AMENDED) The device according to Claim 15, [characterized in that] wherein said first [(15; 18; 21)] and second [(17; 19; 22)] processing units respectively include an interpolator [(21; 22)] able to interpolate the phase shift corresponding to the fractional part determined and to delay the apparatus's clock by a calculated delay on the sending channel [(9)].

METHOD AND DEVICE FOR SYNCHRONIZING A LOCAL CLOCK TO THE CLOCK OF A WIRELESS COMMUNICATIONS NETWORK

The invention relates to a method for synchronizing a local clock of a piece of apparatus to the clock of a wireless communications network to which said apparatus is linked. It also relates to a synchronization device able to function according to said method in such a network.

The invention applies especially in the context of a wireless domestic communications network.

In a bus of the IEEE 1394 type, described in the IEEE standard 1394-1995, each item of apparatus ("node" according to the IEEE 1394 terminology) linked to the bus stamps the packets which it sends with time information indicating the instant at which the packet should be reconstituted by the receiving apparatus.

Each item of apparatus (or "node") linked to the bus includes a 32-bit clock register, incremented at the clock frequency of the bus, namely 24.576 MHz. This register (called "Cycle Time Register" according to the terminology of the IEEE 1394-1995 standard) is divided into three ranges (the 12 lowest-order bits, the 13 intermediate-order bits and the 7 highest-order bits), which are thus incremented respectively at frequencies of 24.576 MHz, 8 kHz and 1 kHz.

When items of apparatus are present which are capable of participating in isochronous traffic, and in order to achieve synchronization of this apparatus, one of them is elected "cycle master node" or "cycle master apparatus" ("Cycle Master" according to the IEEE 1394 terminology). The cycle master apparatus generates an isochronous-frame packet or "cycle-start packet", in IEEE 1394 terminology, every 125 μs, which corresponds to a frequency of 8 kHz. This packet includes the value of the 32-bit clock register of the cycle-master

apparatus at the instant of sending. It is then arranged for an apparatus receiving the packet to slave its own 32-bit register to the values received from the cycle-master apparatus.

The IEEE document 1394-1995 mentioned above relates to the architecture of the serial bus. An additional standard, relating to the interconnecting of several buses by way of what are generally called "bridges", is in the course of preparation. The latest version of this draft currently available from the IEEE bears the reference P1394.1 Draft 0.03, and the date of 18 October 1997.

When several buses are interconnected by means of a wireless bridge, it is vital to transmit the isochronous data with the same clock signal for all the apparatus of the network. The items of apparatus allowing the buses to be linked via a wireless network will from now on be called "portals", according to the terminology adopted by the document P1394.1. With the aim of synchronizing the network as a whole, one of the items of apparatus connected to one of the buses is elected "network cycle-master apparatus" ("net cycle master" according to the IEEE 1394 terminology). The portal which is the network cycle master, or the portal connected to the bus to which the network cycle master is connected, is designated by the name of "cycle server", according to the IEEE 1394 terminology. It is the cycle server which is tasked with transmitting, to the other portals, the clock originating from the network cycle master. The cycle-master apparatus of the other buses thus set themselves to the clock received from their portal.

However, the local clocks of the portals have to be able to be synchronized correctly to the cycle-server clock.

The object of the invention is to propose a solution making it possible to meet this requirement.

To that end, the object of the invention is a method for synchronizing a local clock of a piece of apparatus to a clock of a wireless communications network to which said apparatus is linked, characterized in that, with the frames being transmitted according to a TDMA-type mode, said method includes the following stages:

- a stage of determining the timing-phase shift between the network clock which is received on a receiving channel and the local clock of the apparatus,

- a stage of correcting the local clock of the apparatus on the receiving channel as a function of said phase shift determined, via a first correction of the integer part of the phase shift in the time domain and a second correction of the fractional part for recovery of the residual phase shift.

Thus, with the network clock having been recovered correctly, the sampling of the received signal is carried out with the correct phase, which will allow reception between samples without disturbances.

According to one embodiment, a check window being a predetermined time interval the start of which is defined relatively with respect to the start of the frame sent, one check window per frame being assigned to each sending apparatus, the determination stage includes a stage of detecting a non-varying pattern present at the start of each check window assigned to a piece of apparatus which is the sender of the network clock, said pattern making it possible to supply the instant corresponding to the clock pulse of the network.

According to one embodiment, the detection stage is carried out by correlation between the

network-clock pulse and that of the local clock of the apparatus. In this way, the repeated appearance of the pattern in the received frames makes it possible to be precise in recognizing the exact instant of the start of the check window dedicated to the reference apparatus. The maximum of the correlation carried out at a multiple of the local-clock sampling frequency supplies the instant of the start of the reference-apparatus's check window with a precision equal to a sub-multiple of the local-clock sampling period.

When connectivity is incomplete (that is to say when no direct link exists between at least two portals), the check information nevertheless having to be propagated throughout the wireless network, said method includes, on a sending channel, a stage of transmitting the network clock determined on the receiving channel. Thus, said method makes it possible to propagate the network clock and to transmit it, for example, to a piece of apparatus of the wireless network not in a direct link with the cycle server.

According to one embodiment, the determination stage includes a stage of slaving of the network-clock pulse.

According to one embodiment, said correction of the integer part is achieved by phase-shifting of the local-clock pulse to a sub-multiple of the sampling period of the apparatus.

According to one embodiment, said second correction of the fractional part is achieved in the frequency domain by rotation of vectors expressing the samples received.

According to one embodiment, said stage of determining the timing-phase shift is employed for a third integer-part correction of said phase shift and a fourth fractional-part correction to be carried out on the local clock sent on a sending channel.

According to one embodiment, said fourth correction is carried out in the frequency domain by interpolation of the vectors expressing the samples sent.

According to one embodiment, the fractional-part corrections are carried out in the time domain by interpolation.

According to one embodiment, the phase shift introduced on the sending channel is greater than that introduced on the receiving channel, so as to take account, during the sending of frames, of the processing time due to the coding, to the addressing of the constellation, modulation of the symbols, and with a view to anticipating this processing time when establishing the clock to be sent.

A further object of the invention is a synchronization device suitable for implementing the method according to one of the preceding claims for synchronizing a local clock of a piece of apparatus to the clock of a wireless communications network to which said apparatus is linked, characterized in that, with the frames being transmitted according to a TDMA-type mode, said device includes:

- means for determining the timing-phase shift between the network clock received on a receiving channel and the local clock of the apparatus,

- a first set of means for correcting the apparatus's local clock on the receiving channel as a function of said phase shift determined, comprising first means for correcting the integer part of the phase shift in the time domain and second means for correcting the fractional part of the phase shift able to recover the residual phase shift.

According to one embodiment, said determination means comprise a correlator intended for supplying the network-clock pulse to within a sub-multiple of the

sampling period of the device, and a local-clock slaving unit for locking the local clock to the network clock.

According to one embodiment, said first set of correction means comprises:

- a first unit for timing-phase shifting to the receiving channel for phase-shifting the local-clock pulse by a delay corresponding to the integer part of said phase shift determined,

- a first processing unit for the phase-shifting corresponding to the fractional part determined on the receiving channel.

According to one embodiment, said synchronization device comprises a second set of means for correcting the local clock of the apparatus on a sending channel as a function of said phase shift determined, comprising third means for correcting the integer part of the phase shift in the time domain and fourth means for correcting the fractional part able to recover the residual phase shift.

According to one embodiment, said second set of correction means comprises:

- a second unit for phase-shifting on the sending channel for phase-shifting the local-clock pulse by a delay corresponding to the integer part of said phase shift determined,

- a second processing unit for the phase-shifting corresponding to the fractional part determined on the receiving channel.

According to one embodiment, said first and second processing units respectively include a unit for calculating the Fourier transform, a unit for calculating the inverse Fourier transform, each of the processing units including a phase shifter able to apply, in the frequency domain, a rotation of the vectors representing the samples of the frame.

According to one embodiment, said first and second processing units respectively include an interpolator able to interpolate the phase shift corresponding to the fractional part determined and to delay the apparatus' clock by a calculated delay on the sending channel.

Other characteristics and advantages of the present invention will emerge from the description of the embodiment example which will follow, taken by way of non-limiting example, by reference to the attached figures, in which:

- Figure 1 represents a diagram representing three IEEE 1394 buses linked by a bridge consisting of three portals communicating with each other by wireless transmission,

- Figure 2 represents a synchronization device according to one embodiment of the invention,

- Figure 3 represents a synchronization device according to a variant of the invention.

In order to simplify the description, the same references will be used to designate the elements fulfilling identical functions.

Although the embodiment example relates to IEEE 1394 buses and an associated wireless network, and although the description uses certain terms arising from the terminology associated with this type of bus, the invention is not limited to an IEEE 1394 bus and can be applied in other environments.

Figure 1 represents a network consisting of three IEEE 1394-type buses, referenced 1, 2 and 3, interconnected by a wireless network 50 to which the buses are linked respectively by apparatus known, according to the terminology adopted by the document P1394.1, as "portals", WL1, WL2 and WL3. The portals communicate with each other by wireless transmission, at radio-frequencies in the present instance. It will

be considered that the connecting of the portals constitutes what will be called from now on a wireless "bridge", interconnecting the buses.

These portals WL1, WL2, WL3 are each also members respectively of the buses 1, 2, 3, and thus constitute nodes in the sense of the IEEE 1394 standard in the same way as other items of apparatus 5, 6 connected to the buses. With the aim of synchronizing the network as a whole, the apparatus 4 connected to the bus 1 is elected "network-cycle master apparatus" ("net cycle master" according to the IEEE 1394 terminology). It should be noted that this concept is wider than that of the "cycle master" which is limited to one bus. The network-cycle master apparatus 4, which can also be one of the portals, is designated by the "bridge manager", according to the IEEE 1394 terminology, from among the cycle-master apparatus of the various buses.

The portal WL1, being the portal connected to the bus to which the network-cycle master apparatus 4 is connected, is designated by the name of "cycle server", according to the IEEE 1394 terminology. In this instance, the apparatus WL1 is the cycle server. It is the cycle server WL1 which is tasked with transmitting, to the other portal apparatus WL2, WL3, the clock originating from the network-cycle master apparatus 4. The cycle-master apparatus of the other buses 2, 3 will be set to the clock received from their respective portal apparatus WL2, WL3.

The wireless network uses a mechanism of the TDMA type (standing for "Time Division Multiple Access") for access to the wireless transmission channel, a TDMA frame being subdivided into windows during which the various apparatus can transmit. A check window is a predetermined time interval, the start of which is defined relatively with respect to

the start of the frame, one check window per frame being assigned to each portal apparatus of the wireless network capable of sending.

The portal apparatus WL1 sends the network clock onto the wireless network, and it is received within the apparatus WL2, WL3. For greater clarity, attention will be limited, from now on, to an explanation of the synchronization of the apparatus 5 to the clock. Needless to say, this explanation can be extended to any other apparatus of the wireless network. In the particular case in which a piece of apparatus, not represented, of the wireless network is in a state of incomplete connectivity with the apparatus WL1, that is to say when the apparatus does not have a direct link to the apparatus WL1, it will be considered that the apparatus is synchronized to the clock of an apparatus with which it is in a direct link and which is able to transport the network clock.

Figure 2 represents a synchronization device 7 included in the apparatus WL2 according to a first embodiment of the invention. This device 7 includes two channels 8, 9 respectively for receiving and sending linked to the wireless network 50. The device 7 includes, on its receiving channel 8 receiving the TDMA frames, a phase correlator 10 in parallel with a first phase-shifting unit 11 including a delay line which is known in itself and is able to apply a variable delay to the instant of sampling of the local clock. The operation of this circuit will be explained below. The output of the correlator 10 is linked to the input of a phase estimator 12 another input of which is linked to the output of a first integrator 13 able to accumulate the phase shift of the local clock with the network clock which is received on the receiving channel. The output of the phase estimator 12 is connected to the input of a loop filter 14 the output of which delivers

the phase error to the phase integrator 13 and to a second phase integrator 130. On the receiving channel, the integrator 13 controls one input of the phase-shifting unit 11 and of a phase shifter 15 while, on the sending channel, the integrator 130 controls one input of a second phase-shifting unit 16 and of a phase shifter 17. An output of the phase-shifting unit 11 is linked to a Fourier-transform calculating unit 18 delivering samples in the frequency domain to the phase shifter 16. The output of the phase shifter 16, which is the output of the device 7, is, for its part, linked, for example, to a constellation decoding unit (or "Constellation Demapping Block") which drives a Viterbi decoder, these items not being represented.

The device 7 includes, at the input to its sending channel 9, the phase shifter 17 controlled by the integrator 130 the output of which is linked to an inverse Fourier-transform calculating unit 19 able to transmit the samples in the time domain. These samples are then delivered to the phase-shifting unit 16. The input of the device 7, on the sending-channel side, is linked, for example, to a constellation-addressing circuit followed by a coding circuit, which are not represented. The integrator 13 controls the phase shifter 17 and the second phase-shifting unit 16. The output of the latter is the output of the device 7 which sends out a clock synchronized with that of the network, as explained below.

According to the embodiment represented in Figure 2, the apparatus WL1, in acquisition phase (that is to say after restarting of the network, for example) as well as in steady-state conditions, sends the preamble P which is known to all the items of apparatus of the wireless network, at the start of the check window which is dedicated to it. According to one variant, in order to save energy, the preamble is sent

out only periodically once every q check windows, with q a positive integer. The device 7 detects the presence of this known preamble P by a conventional correlation operation thanks to the correlator 10. The maximum of the correlation is performed at a multiple of the sampling frequency of the device 7, supplying the start instant of the check window of the apparatus WL1 with a precision equal to a sub-multiple of the sampling period of the device 7. In fact, the correlator 10 sends a signal lying between 0 and 1 the maximum value of which corresponds to the detection of the preamble P. The phase estimator 12 receives this latter signal and compares it with the output signal from the integrator 13. Thus, the phase estimator 12 delivers a DC voltage which is a function of the phase difference between the two signals applied to its input. The loop filter 14 lets this voltage through and delivers it to the first and second integrators 13, 130. In that way, as long as the correlator 10 has not detected the preamble P at the start of the check window, the integrator 13 is incremented until the instant of latching onto the network clock. The latching time may, needless to say, be enhanced as a function of the gain of the loop filter 14.

Once the timing-phase shift between the network clock and the clock of the device 7 has been recorded by the integrator 13, the latter causes the phase-shifting unit 11 to phase-shift the local clock by a value equivalent to the integer part of the phase shift recorded. For example, if the local clock has been determined as having a delay of 8.3 bits relative to the network clock, the integrators 13, 130 respectively cause a timing-phase shift of 8 bits by the phase-shifting circuits 11, 16. The residual sampling phase difference, of 0.3 bits, is then less than a sub-multiple of the sampling period in question. The

samples arriving according to a timing logic are then applied to the Fourier-transform calculating unit 18 which transposes them into the frequency plane. However, it is well known that a difference in timing phase in the time domain is expressed by a rotation of vectors (I, Q) obtained at the output of the unit 18. The fine correction of the sampling phase then consists in applying an inverse linear rotation of the output vectors from the unit 18, the slope of this linear phase being supplied by the fractional part calculated by the integrator 13.

When the device 7 has to send, in its turn, it uses the phase-shift information obtained by the integrator 130 and uses the principle seen above for setting on the receiving channel with a view to sending of the clock. The vectors in the frequency domain at the input undergo a correction by a linear phase shift corresponding to the fractional part of the phase shift measured by the integrator 130, and the output samples from the unit 19 undergo a phase shift, in the time domain, corresponding to the integer part of the correction to be applied to the local clock. It will be noted that the phase shift introduced onto the sending channel is greater than that introduced onto the receiving channel so as to take account of the processing time necessary for sending the frames.

This solution of making use of the frequency domain for the fine correction of the phase shift is advantageous when various disturbances, such as multiple echoes, may upset the propagation of the waves, in which case it is preferable to use multi-carrier modulation of the OFDM type.

Figure 3 represents a synchronization device 20 according to one variant of the device 7. In this variant, on the receiving channel 8, the unit 18 and the phase shifter 15 are replaced by an interpolator

able to carry out the correction of the fractional part by interpolation in the time domain. In a parallel manner, on the sending channel, the unit 19 and the phase shifter 17 are replaced by an interpolator 22 also able to carry out the correction of the fractional part by interpolation in the time domain.

CLAIMS

1. A method for synchronizing a local clock of a piece of apparatus (WL2, WL3) to a clock of a wireless communications network (50) to which said apparatus (WL2, WL3) is linked, characterized in that, with the frames being transmitted according to a TDMA-type mode, said method includes the following stages:

- a stage of determining the timing-phase shift between the network clock which is received on a receiving channel (8) and the local clock of the apparatus (WL2, WL3),

- a stage of correcting the local clock of the apparatus (WL2, WL3) on the receiving channel (8) as a function of said phase shift determined, via a first correction of the integer part of the phase shift in the time domain and a second correction of the fractional part for recovery of the residual phase shift.

2. The method according to Claim 1, characterized in that, one check window per frame being assigned to each sending apparatus of the wireless network, the determination stage includes a stage of detecting a non-varying pattern present at the start of each check window assigned to a piece of apparatus (WL1) which is the sender of the network clock, said pattern making it possible to supply the instant corresponding to the clock pulse of the network.

3. The method according to Claim 2, characterized in that the detection stage is carried out by correlation between the network-clock pulse and that of the local clock of the apparatus (WL2, WL3).

4. The method according to one of Claims 1 to 3, characterized in that the determination stage includes a stage of slaving of the network-clock pulse.

5. The method according to one of Claims 1 to 4, characterized in that said correction of the integer part is achieved by phase-shifting of the local-clock pulse to a sub-multiple of the sampling period of the apparatus (WL2, WL3).

6. The method according to one of Claims 1 to 5, characterized in that said second correction of the fractional part is achieved in the frequency domain by rotation of vectors expressing the samples received.

7. The method according to one of Claims 1 to 6, characterized in that said stage of determining the timing-phase shift is employed for a third integer-part correction of said phase shift and a fourth fractional-part correction to be carried out on the local clock sent on a sending channel.

8. The method according to Claim 7, characterized in that said fourth correction is carried out in the frequency domain by interpolation of the vectors expressing the samples sent.

9. The method according to one of Claims 7 to 8, characterized in that the fractional-part corrections are carried out in the time domain by interpolation.

10. The method according to one of Claims 7 to 9, characterized in that the phase shift introduced on the sending channel is greater than that introduced on the receiving channel.

11. A synchronization device suitable for implementing the method according to one of the preceding claims for synchronizing a local clock of a piece of apparatus (WL2, WL3) to the clock of a wireless communications network (50) to which said apparatus (WL2, WL3) is linked, characterized in that, with the frames being transmitted according to a TDMA-type mode, said device includes:

- means (10; 12; 14; 13; 130) for determining the timing-phase shift between the network clock

received on a receiving channel (8) and the local clock of the apparatus (WL2, WL3),

- a first set of means (11; 15; 18; 21) for correcting the apparatus' local clock on the receiving channel (8) as a function of said phase shift determined, comprising first means (11) for correcting the integer part of the phase shift in the time domain and second means (15; 18; 21) for correcting the fractional part of the phase shift able to recover the residual phase shift.

12. The device according to Claim 11, characterized in that said determination means (10; 12; 14; 13; 130) comprise a correlator (10) intended for supplying the clock pulse of the network (50) to within a sub-multiple of the sampling period of the device (7), and a local-clock slaving unit (12; 14; 13) for locking the local clock to the network clock.

13. The device according to one of Claims 11 to 12, characterized in that said first set of correction means (11; 15; 18; 21) comprises:

- a first unit (11) for timing-phase shifting to the receiving channel (8) for phase-shifting the local-clock pulse by a delay corresponding to the integer part of said phase shift determined,

- a first processing unit (15; 18; 21) for the phase-shifting corresponding to the fractional part determined on the receiving channel (8).

14. The device according to one of Claims 11 to 13, characterized in that said synchronization device comprises a second set of means (11; 17; 19; 22) for correcting the local clock of the apparatus (WL2, WL3) on a sending channel (9) as a function of said phase shift determined, comprising third means (16) for correcting the integer part of the phase shift in the time domain and fourth means (17; 19; 22) for

correcting the fractional part able to recover the residual phase shift.

15. The device according to Claim 14, characterized in that said second set of correction means (11; 17; 19; 22) comprises:

- a second unit (16) for phase-shifting on the sending channel (9) for phase-shifting the local-clock pulse by a delay corresponding to the integer part of said phase shift determined,

- a second processing unit (17; 19; 22) for the phase-shifting corresponding to the fractional part determined on the receiving channel (9).

16. The device according to Claim 15, characterized in that said first (15; 18; 21) and second (17; 19; 22) processing units respectively include a unit (18) for calculating the Fourier transform, a unit (19) for calculating the inverse Fourier transform, each of the processing units ((15; 18; 21); (17; 19; 22)) including a phase shifter (15; 17) able to apply, in the frequency domain, a rotation of the vectors representing the samples of the frame.

17. The device according to Claim 15, characterized in that said first (15; 18; 21) and second (17; 19; 22) processing units respectively include an interpolator (21; 22) able to interpolate the phase shift corresponding to the fractional part determined and to delay the apparatus's clock by a calculated delay on the sending channel (9).

ABSTRACT

The invention relates to a method for synchronizing a local clock of a piece of apparatus to the clock of a wireless communications network to which said apparatus is connected, the network clock being sent by a reference apparatus and the frames being transmitted according to a TDMA-type mode. It is characterized by the following stages:

- a stage of determining the timing-phase shift between the network clock which is received on a receiving channel and the local clock of the apparatus,
- a stage of correcting the apparatus' local clock on the receiving channel as a function of said phase shift determined, via a first correction of the integer part of the phase shift in the time domain and a second correction, called correction of the fractional part, able to recover the additional phase shift not recovered by the first correction.

Particular application in domestic wireless communications networks.

Fig. 2

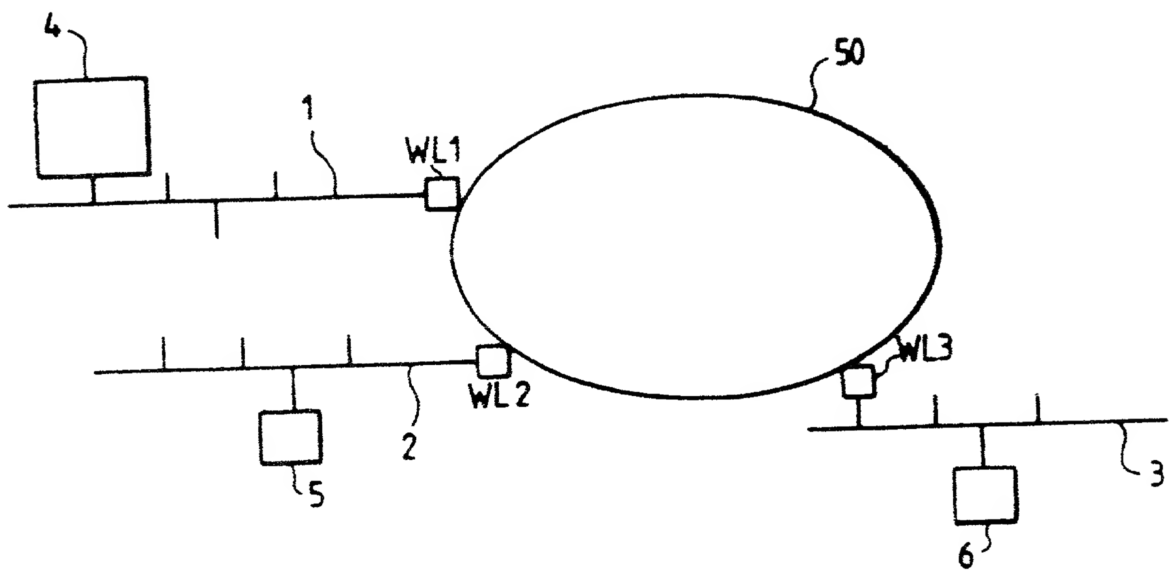

FIG.1

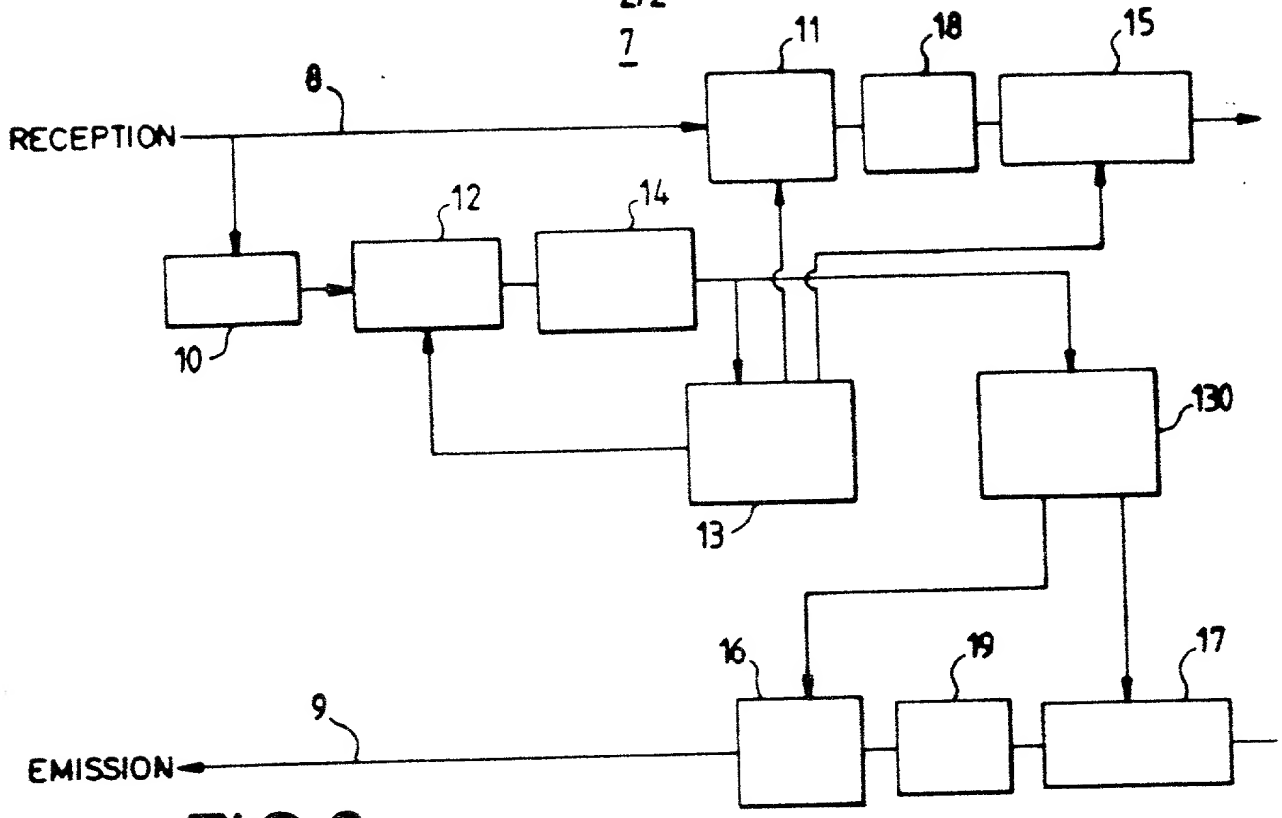
7
8
RECEPTION
11
18
15
12
14
10
130
13
16
19
17
9
EMISSION

FIG.2

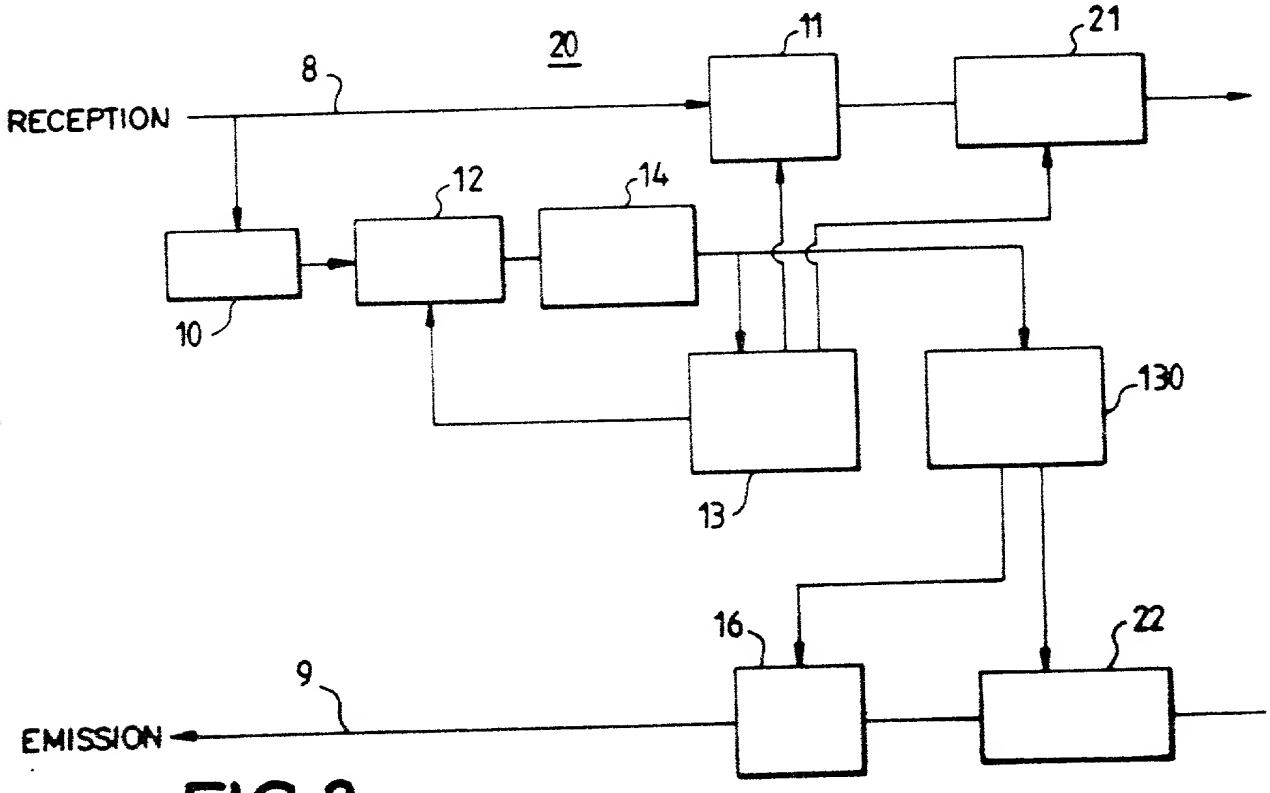
20
8
RECEPTION
11
21
12
14
10
130
13
16
22
9
EMISSION

FIG.3

DECLARATION FOR UNITED STATES PATENT APPLICATION,
POWER OF ATTORNEY, DESIGNATION OF CORRESPONDENCE ADDRESS

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and that I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

METHOD AND DEVICE FOR SYNCHRONIZING A LOCAL CLOCK TO THE CLOCK OF A WIRELESS COMMUNICATIONS NETWORK

the specification of which
(CHECK ONE) ( ) is attached hereto.
(XX) was filed on May 3, 2001, Application Serial. No. 09/831085
and was amended on .

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with 37 CFR 1.56(a).

I hereby claim foreign priority benefits under 35 USC 119 of any foreign application(s) for patent, utility model, design or inventor's certificate having a filing date before that of the application(s) on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
Number	Country	Date Filed	Yes	No
9813939	FR	November 05, 1998	xx	

I hereby claim the benefit under 35 USC 120 of any US Application(s) listed below, and, insofar as the subject matter of each of the claims of this Application is not disclosed in the prior US application in the manner provided by the first paragraph of 35 USC 112, I acknowledge the duty to disclose information which is material to the examination of this application in accordance with 37 CFR 1.56(a).

Serial No.: Filed:

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both, under of 18 USC 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint the following attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: Joseph S. Tripoli (Reg. No. 26,040), Dennis H. Irlbeck (Reg. No. 26,372), Eric Herrmann (Reg. No. 29,169) and Joseph J. Laks (Reg. No 27,914) Telephone: (609) 734-9813.

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